Increased blood viscosity and tachypnoea in infants of diabetic mothers

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SUMMARY Tachypnoea was significantly more common in class B than in class A or C infants of diabetic mothers. Whole blood viscosity at a standardised packed cell volume and moderately low shear rate was significantly higher in infants of diabetic mothers with tachypnoea than in those without tachypnoea or healthy controls.

Infants of diabetic mothers often exhibit abnormal clinical findings in the early postnatal period, including hypoglycaemia and tremulousness, as well as tachypnoea, which may only commence several hours after birth. They also have a high incidence of polycythaemia, with an associated increase in blood viscosity.[1] Adults with diabetes may develop increased blood viscosity due to slightly raised plasma viscosity, decreased individual red cell deformability, and more pronounced red cell aggregation.[2 3]

We studied infants of diabetic mothers during their first two postnatal days to evaluate their blood viscosity independently of their packed cell volume, and to determine whether there was any relation between blood viscosity and tachypnoea in these infants.

Subjects and methods

Forty three infants of diabetic mothers with gestational ages between 37 and 41 weeks were selected at random after birth and followed prospectively. They were categorised according to White's classification of maternal disease.[4] Each infant was evaluated by random observations between 12 and 24 hours of age. Resting respiratory rates were counted for one minute intervals on at least two occasions during three to five minute periods of inactivity. The infant was classified as tachypnoeic if these rates were consistently $\geq$60/minute. A sample of venous blood, with dry heparin as the anticoagulant, was obtained within 36 hours of birth and studied on the same day. Blood from 27 term neonates served as controls. This was taken at delivery, or by venipuncture for clinical reasons, from infants who subsequently were found to have no major illness. Appropriate parental consent was obtained.

The packed cell volume of each blood sample was determined by a standard micromethod and was then adjusted to 50% ($\pm$1%) by addition or removal of an appropriate volume of autologous plasma. The standardised viscosity at specific shear rates was measured at 37°C in a 0·5 ml sample of blood by means of a Wells-Brookfield cone-plate viscometer (Model LVT) equipped with a 0·8° cone spindle CP–80 and was expressed in centipoise. During the latter part of the study, when the sample volume was sufficient, plasma viscosity was determined independently.

The incidence of tachypnoea in the categories of infants of diabetic mothers was compared by a χ^2 test with Yates's correction for small numbers, and viscosity differences at specific shear rates were evaluated by Student's t test.

Results

Fifteen of the 43 infants of diabetic mothers developed tachypnoea: three of 16 in class A, 10 of 17 in class B, one of seven in class C, and one of three in whom the class was uncertain. The incidence of tachypnoea in class B was significantly higher than in class A ($p<0·05$). There was no significant difference between the mean packed cell volumes of the infants of diabetic mothers with and without tachypnoea (58% *v* 57·2%). At the standardised packed cell volume of 50%, and at a moderately low shear rate (11·25 sec^{-1}), the whole blood viscosity of those infants with tachypnoea was significantly higher than infants without tachypnoea and controls ($p<0·01$) (Table). At this shear rate—that is, 11·25 sec^{-1}—standardised whole blood viscosity in class B infants was higher than in controls ($p<0·01$). At the somewhat higher shear rate of 90 sec^{-1}, however, the above differences among the groups were not significant.

The limited number of studies performed on plasma showed a trend towards higher viscosity in infants of diabetic mothers with tachypnoea and in class B infants compared with controls, but the differences were not significant (Table).

Table *Standardised viscosity determinations in infants of diabetic mothers and control neonates. Values are mean (SD)*

	Controls	*Infants of diabetic mothers*					
		Grouped by class				*Grouped by respiratory rate*	
		All	*A*	*B*	*C*	*<60*	*≥60*
n=	27	43	16	17	7	28	15
Birth weight (kg)	3·27	3·55	3·65	3·39	3·49	3·54	3·57
	(0·44)	(0·63)	(0·61)	(0·68)	(0·53)	(0·69)	(0·71)
Venous packed cell volume (%)*	52·5	57·5	58·4	57·9	54·9	57·2	58·0
	(5·1)	(6·8)	(7·2)	(6·7)	(6·6)	(6·9)	(7·0)
Viscosity at 50% packed cell volume (cp)							
Shear rate (sec^{-1}):							
11·25	8·62	9·14	8·81	9·77	8·69	8·73	9·89
	(1·06)	(1·43)	(1·24)	(1·51)	(0·94)	(1·24)	(1·48)
90	5·14	5·27	5·20	5·39	5·19	5·17	5·45
	(0·39)	(0·58)	(0·59)	(0·54)	(0·50)	(0·51)	(0·68)
Plasma viscosity (cp)							
n=	14	12	5	7	–	5	7
Shear rate (sec^{-1}):							
90	1·28	1·37	1·29	1·42	–	1·30	1·41
	(0·19)	(0·15)	(0·14)	(0·15)		(0·13)	(0·16)
225	1·19	1·28	1·22	1·32	–	1·26	1·29
	(0·14)	(0·13)	(0·12)	(0·13)		(0·12)	(0·15)

*Postnatal sampling times not controlled; values not comparable for statistical purposes.
Birth weight: Controls (a) *v* all infants of diabetic mothers, $0{\cdot}1 > p > 0{\cdot}05$; (b) *v* class A infants, $p < 0{\cdot}05$.
Viscosity at 50% packed cell volume and shear rate 11·25 sec^{-1}: Controls *v* (a) class B infants; (b) infants with respiratory rate >60, $p < 0{\cdot}01$. Infants with respiratory rate <60 *v* infants with respiratory rate >60, $p < 0{\cdot}01$.
Plasma viscosity at shear rate 90 sec^{-1}: Controls *v* (a) class B infants; (b) infants with respiratory rate ≥60, $0{\cdot}2 > p > 0{\cdot}1$.
Plasma viscosity at shear rate 225 sec^{-1}: Controls *v* class B infants, $0{\cdot}1 > p > 0{\cdot}05$.

Discussion

The determinants of whole blood viscosity in vivo and in vitro are complex, involving both red cell and plasma factors. In the present study we observed an increase in whole blood viscosity in class B infants that was independent of their raised packed cell volumes, which was statistically higher than the controls at the moderately low shear rate (11·25 sec^{-1}) but not at the higher shear rate (Table). In general, our findings in infants of diabetic mothers were consistent with those described in adults with diabetes at similar shear rates.[2] The more pronounced increase in low shear viscosity possibly indicates mechanisms mediated by enhanced red cell aggregation, reduced erythrocyte deformability, or increased plasma viscosity. Decreased red cell deformability has been shown in blood from infants of diabetic mothers by Linderkamp *et al.*[5] The increase in plasma viscosity observed in our study did not reach significance, but this might have been related to the small number of samples.

The higher viscosity in class B infants compared with class A could be a reflection of either the severity and duration of the diabetic state in the mother, or, as seems more likely, of the efficacy of maternal diabetic control. Ongoing studies comparing viscosity with glycosylated haemoglobin concentrations should help to elucidate these differences.

The relation between viscosity and tachypnoea is of particular interest. Tachypnoea and respiratory distress have generally been regarded as clinical manifestations of neonatal polycythaemia (venous packed cell volume persisting above 65%) and as possible indications for a partial replacement transfusion in an infant with polycythaemia. A recent study on newborns with polycythaemia and hyperviscosity showed echocardiographic findings consistent with increased pulmonary vascular resistance that normalised after partial replacement transfusion.[6] It should be emphasised, however, that, although hyperviscosity with or without polycythaemia might represent a mechanism for the production of tachypnoea in infants of diabetic mothers, one cannot exclude the possibility that tachypnoea and hyperviscosity might each be independent neonatal variables reflecting the efficacy of metabolic control of maternal diabetes.

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The 'Sport-tester': a device for monitoring the free running test

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SUMMARY A cheap telemetric device, the 'Sport-tester', has been shown to be useful in monitoring the free running test for bronchoconstriction.

The free running test is one of the most potent bronchoconstrictive stimulants in subjects with bronchial hyperreactivity.[1] The test consists of running for six to eight minutes under standardised conditions, at a workload equivalent to 60–80% of the subject's maximal aerobic power.[2] Even though it is difficult to measure workload directly, an indirect estimate may be obtained by measuring heart rate during the exercise.[3] Hitherto, monitoring of heart rate during a free running test has involved the use of telemetry, which is generally expensive and therefore not widely employed. In the present study we examined a simple inexpensive form of heart rate telemetry during free running tests in children.

Subjects and methods

The device tested was the self monitoring 'Sport-tester PE 2000' (available in the United Kingdom from Duffield Medical Equipment Ltd, Belper, Derbyshire, at £97·90 +VAT), which consists of two parts (Fig. 1): (1) the 'transmitter', which is a battery operated electronic electrocardiogram (ECG) monitor strapped to the anterior chest wall with a rubber belt, and (2) the 'receiver', which is an electronic watch with an antenna housing, capable of receiving signals from the transmitter. The mean heart rate over five second epochs is displayed as a digital read out. Moreover, the receiver can store readings of heart rate every 30 seconds for up to 64 minutes for later recall. The subject must wear the receiver as a wrist watch while running, so that the receiver-transmitter distance is not more than one metre.

The reliability of the 'Sport-tester' was checked by comparing it with the readings of a standard ECG monitor (Kontron 105–000C) in 14 healthy children (eight boys and six girls) aged 8–12 years, who performed a submaximal treadmill exercise test while being monitored simultaneously by the 'Sport-tester' and ECG.

The 'Sport-tester' was then used to monitor the heart rate during two types of running: 'fast' running when the subjects were instructed to run as fast as they could and 'moderate' running in which they were asked to run at a comfortable pace. Twenty four normal healthy children (11 boys and 13 girls) aged 6–11 years participated. Each period of exercise lasted for six minutes, with an interval of 90 minutes between the two tests.

Finally, the 'Sport-tester' was used to monitor a group of 240 unselected children 6–12 years old, taking part in a fast free running test.

Results

The correlation between the results obtained from

Fig. 1 *The 'Sport-tester', showing the transmitter (top) and the receiver (bottom).*